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CONSTRUCTION OF A BUSINESS BAROMETER BASED UPON ANNUAL DATA

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I. Statement of the Problem

A barometer showing the fluctuations of business and industrial activity may be put to many uses. Economists and sociologists need such a barometer when dealing with the phenomena of a dynamic society; government officials when handling the problem of unemployment or when considering the advisability of inaugurating large government undertakings; manufacturers and dealers when considering the desirability of making extensions to their plants or of contracting or expanding their purchases, sales or commitments; bankers need a business barometer to guide them in extending or calling their loans and discounts; and investors need one to direct their purchases and sales of securities.

Various statistical series, such as bank clearings, commodity prices, coal and iron production, have been used by various writers as indices of general business condition. Other series, such as prices of stocks, commercial failures, and surplus bank reserves, have been recommended for forecasting such condition. Professor Irving Fisher bases his forecasts upon changes which take place in the series entering into his equation of exchange, especially upon changes in the velocities of circulation of deposit currency and money; maxima being reached, he holds with justice, in the year of the occurrence of a crisis.[1] However, these velocities must be estimated from inadequate data and hence are subject to a large possible error.[2]

A governmental commission has considered the problem of the construction of a business barometer. After the crisis of 1907

[1] Irving Fisher, *Purchasing Power of Money*, p. 270.

[2] Irving Fisher, "The Equation of Exchange for 1914 and the War," AMERICAN ECONOMIC REVIEW, vol. V (June, 1915), p. 407.

the French government appointed a commission "*chargée d'étudier les mesures à prendre pour atténuer les chômages résultant des crises économiques périodiques.*" This commission was composed of 44 government officials, senators, deputies, bankers, statisticians, and economists. The commission recommended that, in order to reduce unemployment in time of industrial depression, the planned governmental undertakings be prosecuted more vigorously at such times than in time of industrial activity, making specific recommendations as to the handling of government budgets, appropriations, and reserve funds so that the responsible officials would be given sufficient latitude to accomplish the purpose.[3] The commission realized that its most important, and most difficult, task was to find some index of industrial condition that could be used as a reliable guide in regulating governmental activity. It sought the answer to this question: "*dans la multiplicité des phénomènes qui s'enchaînent et se conditionment les uns les autres, existe-t-il des signes révélateurs de la dépression prochaine?*"[4] Investigation led the commission to recommend, as most significant, the following statistical indices of business condition:[5]

1. Commercial loans and discounts of the Bank of France;
2. Cash reserves of the Bank of France;
3. Prices of raw materials, of foodstuffs, and of all commodities;
4. Foreign commerce of France;
5. Consumption of coal;
6. Price of pig-iron;
7. Traffic of railroads;
8. Unemployment.

The dates of maxima and minima of the various indices were compared with each other and with the dates of crises. "Certain of these indices," says the report, "appear to precede crises and, in some measure, to forecast them. Others are concurrent."[6] A composite business barometer was not constructed.

Within the last half-dozen years two organizations in the United States—Babson's and Brookmire's—have developed a service for business men, bankers, and investors in which fundamental statistics are used in constructing a business barometer and for fore-

[3] See pp. 6 and 65 of *Rapports sur les Indices des Crises économiques et sur Mesures financières propre à atténuer les Chômages résultant de ces Crises,* a government report of 78 pages presented in 1911.

[4] *Ibid.,* p. 13.

[5] *Ibid.,* p. 39.

[6] *Ibid.,* p. 38.

casting business conditions. Both services use a business barometer obtained by averaging a number of statistical series. Both Babson and Brookmire claim that variations in certain series precede variations in the business barometer and hence are especially valuable for forecasting. For instance, Brookmire says, "A rise in the stock market for three or four months always precedes and forecasts business improvement."[7] On the other hand, Babson states that, "In some instances the investment market has been ahead of general business, but more often it has only reflected conditions already revealed by other statistics."[8] Babson maintains that, "The production of pig-iron forecasts the condition of the whole building industry and construction of all kinds"[9] and that "the turning point of the statistics on new building has been from two years to six months earlier than the general crisis."[10]

Figure 1 presents the business barometers of Brookmire and Babson. Brookmire bases his forecasts upon three graphs, as follows:

1. A graph to show the price trend of thirty-two leading stocks (not shown in Figure 1).
2. A business graph based upon the statistics of bank clearings, railroad earnings, pig-iron production and prices, commodity prices, imports, building, and immigration (the shaded graph of Figure 1).
3. A banking graph based upon reserves, deposits, the rate of commercial paper, the percentage of loans to deposits and the percentage of reserves to loans (not shown in Figure 1).

The secular tendency of each series is computed and eliminated, Brookmire tells us, the method not being uniform for all the data, before the series are combined. The horizontal line *OP* (Figure 1) thus represents "normal." General liquidation, Brookmire states, "is always forecasted by the fall in the banking and stock market graphs, the stock market especially being an invaluable barometer to the business man in warning him of a period of declining prices and business reaction."[11]

Babson's business barometer is obtained by combining the following statistics:

[7] American Economic Review, vol. III (March, 1913), pp. 57-58.
[8] Babson's *Reports*, 1914, chart no. 609.
[9] *Ibid.*, chart no. 612.
[10] *Ibid.*, chart no. 598.
[11] American Economic Review, vol. III (March, 1913), p. 58.

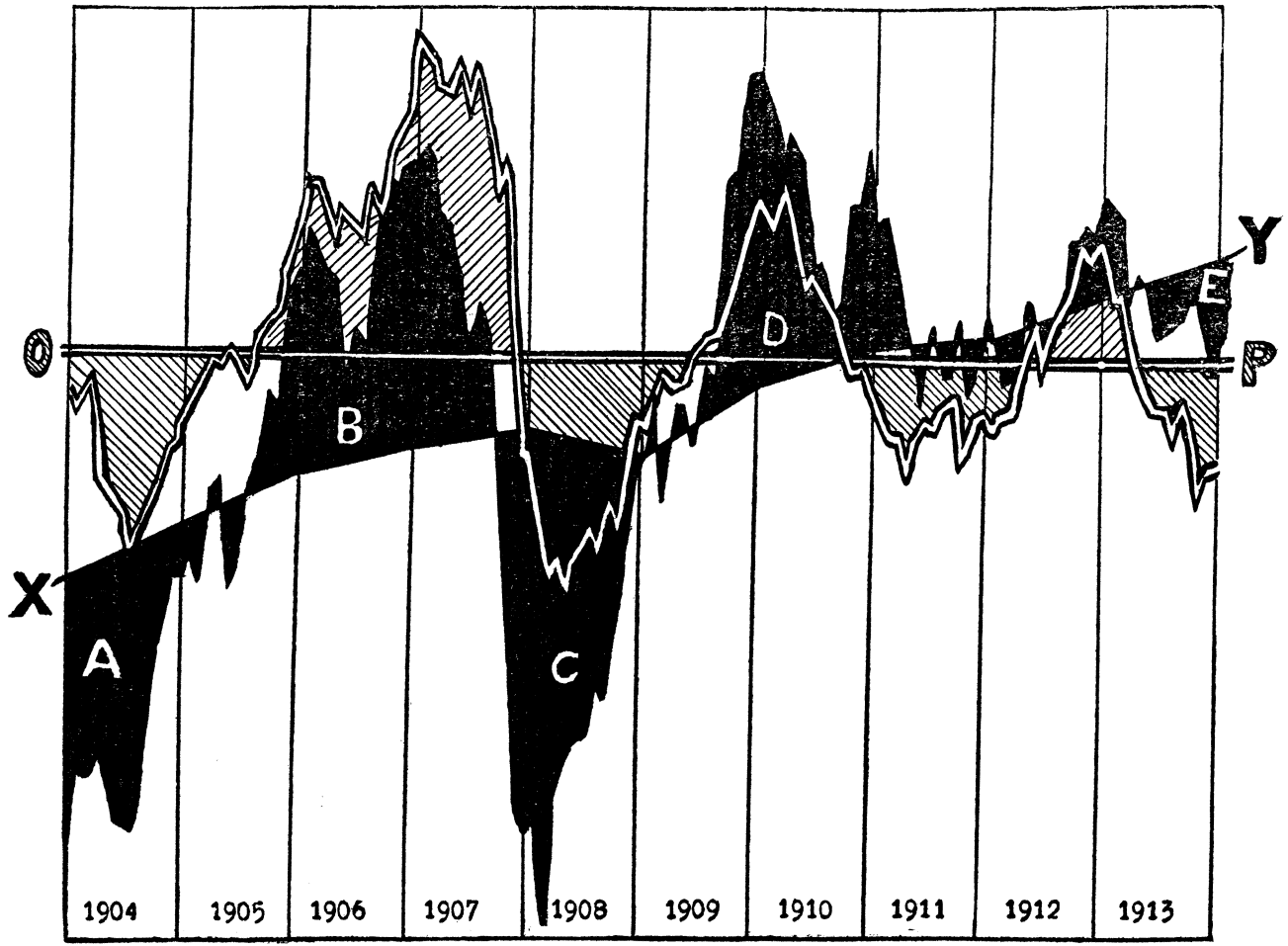

FIGURE 1. - Babson's (black) and Brookmire's (shaded) composite barometers

1. A group indicating mercantile conditions based on statistics of immigration, new building, commercial failures, and bank clearings.
2. A group indicating monetary conditions, based on commodity prices, foreign trade, foreign money rates, and domestic money rates.
3. A group indicating investment conditions based on conditions of leading crops, railroad earnings, political factors (estimated), and prices of stocks.

All the series are combined in the composite business barometer of Figure 1 (black). Babson does not eliminate the secular trend before combining the various series, but he computes it each year for the series entering the composite plot. It is shown in the accompanying chart by the broken line XY. Babson bases his predictions on "the assumption that Newton's fundamental law of Action and Reaction applies to business as well as to mechanics, chemistry, and every known art and science."[12] Areas above and below the line of secular trend (XY), he holds, must be equal. His line of trend or normal growth, which changes slope every year, is drawn on the basis of this assumption.

In a letter to me dated October 7, 1915, Mr. Babson explained his assumptions and method as follows:

When the two factors of time and intensity are multiplied to form an area, the sums of the areas above and below said line of normal growth X-Y must, over sufficiently long periods of time, be equal, provided the line X-Y is properly located and enough subjects are therewith included, with all properly weighed and combined. The method by which this line is formed is the following: A starting point is obtained by arbitrarily drawing a line with the proper trend thru the curve of a completed cycle, to make the areas above and below the said line equal for that first completed cycle. This gives a starting point. This line is then carried along from year to year in accordance with the trend of bank clearings until the second cycle has been completed. At the end of this second cycle the size of the areas is then noted. Up to the present they have been nearly enough equal for all practical purposes, but if not, the right is reserved to make a slight adjustment at the end of each cycle—in order that any errors shall not be cumulative. Of course if this correction is considerable, the case falls down, but if only a slight correction is needed, it seems allowable. In other words, instead of drawing the Plots to prove the law of action and reaction, the law of action and reaction is assumed (1) to make the Plot as useful as possible for immediate use, and (2) for correcting possible errors due to lack of completeness of data.

[12] Babson's *Reports*, 1914, preface.

In a preceding paragraph I mentioned the irregularity of slope of the "line of normal growth" that Babson secures by his method of equal positive and negative areas. My concept of normal growth, differing from that of Mr. Babson, is that of an element which can be represented by a smooth line or curve which sweeps along from year to year undisturbed, except in its *general* position and slope, by the actual items of the statistical series. The normal line, of course, should "fit" the original data and be determined by them. Marshall says that "when 'normal' prices are contrasted with temporary or market prices, the term refers to the dominance in the long run of certain tendencies under given conditions,"[13] and that "there are very gradual or *Secular* movements of normal price, caused by the gradual growth of knowledge, of population and of capital, and the changing conditions of demand and supply from one generation to another."[14] Marshall thus emphasizes the *gradualness* of the secular changes. In its estimates of intercensal population the federal Bureau of the Census assumes that there is a uniform addition to the population from year to year: *i. e.*, that the line of growth between censal years is straight. Experience has shown that the straight line fits the data excellently. For a period of fifty or one hundred years, rather than ten, the compound interest law with a uniform *rate* of change gives a better fit. In either case, however, the secular trend is represented by a smooth curve.

The method of eliminating the secular trend used by the Brookmire Economic Service is as follows: first, find the arithmetic average increase in the items for the ten years preceding the date of the item to be adjusted; second, subtract the growth increment thus found from the eleventh item for which adjustment is desired. However, the method is abandoned in certain cases, the Service refusing "to be committed to any one method or any limited number of factors."[15]

[13] Alfred Marshall, *Principles of Economics* (6th ed.), p. 36.

[14] *Ibid.*, p. 379.

[15] In a letter dated September 24, 1915, Mr. Warren F. Hickernell, editor of the Brookmire Economic Service, replied to my inquiry concerning his method of eliminating the secular trend as follows:

"In constructing our Barometer Chart we eliminate both the seasonal variation and the normal growth where these exist. The seasonal variation is eliminated by taking a ten-year average and dividing the actual figure by the deviation of the monthly average from the yearly average.

"In taking out the normal growth we also use a ten-year period as a base.

The Brookmire method has the defect of starting from an arbitrary assumption. Why should ten years, rather than five or twenty, be used in computing the secular trend? If the length of the business wave does not, in fact, coincide with the arbitrary period chosen at the outset or if it be irregular, the results are vitiated. Moreover, it must be remembered that we are eliminating the growth element in order to obtain information concerning the business cycle. The assumption of a cycle of definite length anticipates the conclusion. This point has been adequately discussed by A. L. Bowley.[16] There is a further defect in this method: it can not be applied to the first ten items of the series.

Professor M. T. Copeland suggests the following method of eliminating normal growth and seasonal fluctuations from monthly data: "For each subject let a monthly index number be obtained by dividing the actual figure for the month by the average for that month during the ten preceding years. . . . By using the ten-year monthly averages, seasonal fluctuations are automatically allowed for, and by always taking the ten preceding years as the base, provision is made for normal growth."[17] Copeland's method involves the same assumption as that of Brookmire: *i. e.*, recurrent business cycles of a ten-year period. This assumption should not

We stick to no one method, as the test of a good index is that its value shall not be impaired whether we use a movable or a fixed base. In case of pig-iron production or bank clearings, we can find the normal growth for a ten-year period and deduct the growth increment from the eleventh year in order to get the barometer figure. When using this movable base it is necessary to chop off the earliest year of the ten-year period and add on the eleventh year in order to form a new base for determining the rate of increase to be used in correcting the twelfth year. This continuation of a progressive ten-year base is used for the thirteenth year, etc. In the case of some business barometers, such as building permits, the movable base cannot be used from the beginning. It is impossible to get satisfactory statistics of building permits previous to 1900, and so it is necessary during the first ten years of our data to eliminate the normal growth of each year by using the average rate of increase for the period. In the eleventh year we can begin the use of a movable base. .....

"In constructing the charts I refuse to be committed to any one method or any limited number of factors. I also reserve the right to eliminate any factor when for legislative or other causes that factor ceases to be a good barometer. I always make a Barometer Chart of each factor separately before including it in a composite index."

[16] *Elements of Statistics* (3d ed.), pp. 151-154.

[17] "Statistical Indices of Business Conditions," *Quarterly Journal of Economics*, May, 1915, pp. 554, 556.

be made if our object is to ascertain the phenomena of the business cycle. The Brookmire and Copeland methods give substantially identical results.[18]

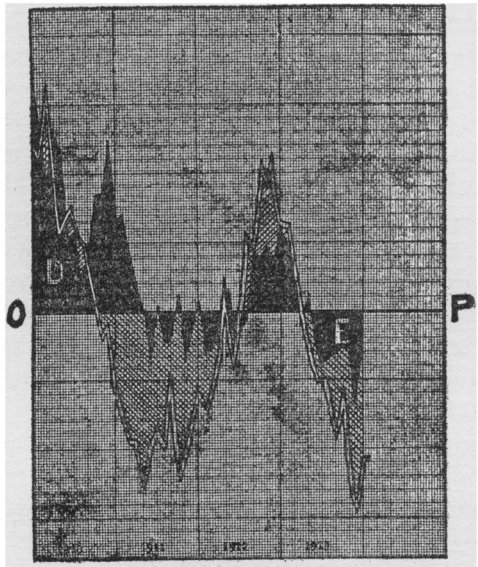

FIGURE 2. - Detail of Babson's (black) and Brookmire's (shaded) composite business barometers, 1910-1915. Secular trend is OP in both cases.

A lack of correspondence of the Babson and Brookmire graphs is especially noticeable in the years 1910 and 1911. In Figure 2 the adjusted graphs are plotted together for the period 1910-1913, Babson's line of "real prosperity" (XY) being made to coincide with Brookmire's "normal" line (OP). In the latter part of 1910 and beginning of 1911 the Babson graph develops a decided positive area while the Brookmire graph shows a marked negative or subnormal area.

The criticisms that I have to offer of both Babson's and Brookmire's barometers are: first, that they are constructed of heterogeneous sets of statistics whose selection or grouping is based on no scientific analysis; second, the method of eliminating the secular trend is not satisfactory; and, third, it would appear impossible for any one desiring so to do, to check up Babson's or Brookmire's results. Babson's "law of action and reaction" is,

[18] This is the conclusion of W. F. Hickernell in "Building Business Barometers: Dr. Copeland's Method," *Moody's Magazine*, December, 1915, pp. 574-576.

of course, only an hypothesis supported by arguments based on analogy rather than upon statistical investigation. If that law does apply to economic phenomena, the exact way in which it does apply would have to be ascertained by careful statistical research. Such research has not been made. I object, then, not to the use of a variety of industrial and financial statistical series in constructing a business barometer but rather to their use in a naïve or rule-of-thumb manner. However, let me say that both the Babson and Brookmire organizations have performed a most valuable service in emphasizing the importance of fundamental statistics and in making them readily available.

The problem which I wish to discuss in this paper is twofold. First, what statistical series should logically be combined to secure a barometer of general business conditions for the United States? Second, what series have variations precedent to the variations in the business barometer thus obtained and, therefore, offer a reliable basis for forecasting business conditions?

II. The Data and Method of Attack

The period 1879-1913 was selected for investigation because of its relative homogeneity of monetary and business conditions, and because it is long enough to include several sub-periods of industrial prosperity and depression. From 1879 to 1896 we have, in general, a series of years of falling prices, and from 1897 to 1913 a series of years of rising prices, but during the whole period the United States was on a gold basis. A short summary of the business conditions of the period selected for study follows.[19]

The business depression which followed the crisis of 1873 lasted until the summer of 1879. Good crops then brought a tide of prosperity which culminated in 1882. Business declined in 1883 and an acute crisis came in May, 1884. This crisis, however, was neither as general nor as disastrous in its effects as that of 1873.

Recovery from the crisis of 1884 was prompt. Although 1885 was the dullest year of the decade, 1886 was a good business year and the high tide of prosperity was reached in 1889. In the summer and autumn of 1890 there was a monetary stringency in the United States, accompanying the financial prostration of England which reached its climax with the Baring failure of November 15.

[19] This summary of conditions is adapted from Mitchell's *Business Cycles*, pp. 45-88.

However, general business was active. The liquidation that set in after the stringency of 1890 was checked by the "concurrence of bad harvests in Europe and abundant harvests in America. . . . In the United States the volume of business transactions in 1892 was greater than ever before." Liquidation was, evidently, merely postponed, for in May, 1893, "one of the most violent panics in the country's history broke out."

Deep depression ruled in 1894; in 1895 there was a revival followed by a relapse and return to depression and panicky conditions in financial markets in 1896. In the second half of 1897 improvement set in and continued to its high tide in 1899. After a pause in activity in 1900 prosperity in general business continued until 1904. A stock exchange panic occurred in May, 1901, and a "rich man's panic" of "undigested securities" occurred in 1903.

The mild industrial depression of 1904 gave place to prosperity in 1905 which reached its extreme in 1906. The crisis and panic of October, 1907, was followed by a deep depression of trade and industry in 1908. The recuperation in 1909 and 1910 was followed by a mild depression in 1911. Renewed activity of business occurred in 1912 but a halt came in the early part of 1913. The second half of 1913 and first half of 1914 made up a year of hesitation in business.

The following series of annual statistics for the United States were examined for the period just described, 1879-1913:[20]

[20] The series of wholesale prices of commodities was secured by combining the indices of prices of "all articles" of the Aldrich Report and the indices of prices of "all commodities" of the Bureau of Labor Statistics. The former series was adjusted to the base of the latter by multiplying the former by the ratio 112.9 : 92.3, the antecedent being the Labor Bureau index for 1890 and the consequent being the Aldrich index for the same year.

Gross receipts, net earnings and new mileage of railroads are Poor's figures taken from *Statistics for the United States, 1867-1909* (National Monetary Commission Report) and Babson's *Reports*; exports, imports and balance of trade are from the same sources.

Coal, steel, and pig-iron produced, and immigration are from the *Statistical Abstract for the United States.* Liabilities of business failures are Dun's figures taken from the same source.

Ratio of loans to resources and ratio of cash to deposits of banks are from Babson's *Business Barometers.*

Price of pig-iron, surplus reserves of New York associated banks and percentage of business failures are from Babson's *Reports.* The business failures from 1902 to 1913 are the average of Dun and Bradstreet's; previous to 1902 they are Dun's only. The striking of such an average is, in general, bad

1. Wholesale prices of commodities;
2. Gross receipts of railroads;
3. Net earnings of railroads;
4. Coal produced;
5. Exports from the United States;
6. Imports into the United States;
7. Pig-iron produced;
8. Price of pig-iron;
9. Immigration (fiscal year);
10. Shares sold on the New York Stock Exchange;
11. Average price of shares sold on the New York Stock Exchange;
12. New York clearings plus five times outside clearings (called clearing index);
13. Clearing index divided by relative wholesale prices (called corrected clearing index);
14. New railroad mileage;
15. Per cent of business failures;
16. Liabilities of business failures;
17. Balance of trade;

statistical practice. However, in this case we are measuring correlation, and the relative fluctuations rather than the absolute figures are significant. In 1901 Bradstreet's percentage was .88 and Dun's .90; from that date the fluctuations are similar.

Shares sold on the New York Stock Exchange and average price of shares sold are the figures reported by *The Commercial and Financial Chronicle,* being taken from that journal and from *Statistics for the United States.*

The clearing index and the corrected clearing index are compiled from figures taken from *Statistics for the United States* and Babson's *Business Barometers.* The clearing index is obtained by combining the New York clearings and five times outside clearings, then reducing the series to relative numbers with 1890-1899 as the base. The weighting is in accordance with Fisher's conclusion that "on the basis of 1909 figures, five times the outside clearings plus once the New York clearings should be a good barometer of check transactions" (*Purchasing Power of Money,* p. 447). The corrected clearing index was obtained by dividing the clearing indices by the indices of relative wholesale prices for the corresponding years.

The weighted index numbers of the yield per acre of nine leading crops are Moore's figures (*Economic Cycles,* p. 130) supplemented by the indices for 1912 and 1913 computed by the writer. The nine crops and their respective weights are: corn, 36; wheat, 12; oats, 9; barley, 3; rye, .7; buckwheat, .3; potatoes, 6; hay, 16; cotton, 17. The period 1890-1899 was taken as the base. "The method of weighting that was adopted in this particular case was to assign to each crop an importance proportionate to its value as compared with the total value of the nine crops in 1911" (*Economic Cycles,* p. 104).

The average rates of interest on ten railroad bonds, long and short commercial paper and call loans are from Mitchell's *Business Cycles,* p. 146.

18. Weighted index numbers of the yield per acre of nine leading crops (Moore's figures);
19. Ratio of loans to resources of banks;
20. Ratio of cash to deposits of banks;
21. Surplus reserves of New York associated banks;

For the period 1890-1911 (Mitchell's figures):

22. Average rate of interest on ten railroad bonds;
23. " " " " " 4-6 month commercial paper;
24. " " " " " 60-90 day " "
25. " " " " " call loans in New York.

The method of attack selected for the problem under discussion involves:

1. The selection of a first approximation to a business barometer to be used as a standard with which to compare the other series. Wholesale prices of commodities was the standard chosen.

2. The elimination of the growth element or secular trend from each series and the securing of the periodic variations or "cycles."

3. Computation of the degree of correlation between the cycles of each series and the cycles of wholesale prices, for concurrent items, also for various degrees of lag in prices and in the given series; the object being the determination of the point of maximum correlation. The questions to be answered are: Do the fluctuations synchronize? If not, in which direction is the lag and how long?

4. Computation of the degree of correlation between the first differences of cycles (*i. e.*, changes, plus or minus, of each year as compared with the preceding year) of each series and of prices for concurrent items and for various degrees of lag; the object being the securing of further evidence concerning the point of maximum correlation as found in number 3 above.

5. Combination of the various series having concurrent fluctuations with wholesale prices into a business barometer.

6. Computation of the degree of correlation between the cycles of each series and of the business barometer as obtained in number 5 above to verify the selection of the series composing the barometer.

7. Computation of the degree of correlation between the first difference of each series and of the business barometer as a further confirmation of the selection of the series composing it.

8. Combination of the various series having the maximum correlation for a lag of one year in relative wholesale prices into a one-year forecaster.

9. Computation of the degree of correlation between the cycles and first differences, respectively, of the one-year forecaster and of the business barometer in order to determine the accuracy with which the former forecasts the latter.

III. Wholesale Prices as a First Approximation

The series of wholesale prices of commodities was taken as a first approximation to the business barometer because of the con-

sensus of opinion of writers on business cycles that such cycles are preëminently characterized by price movements, culminating in crises and reaching bottom at times of depression. For instance, Juglar's studies[21] lead him to define an economic crisis as a "stoppage of the rise of prices"; Mitchell's account[22] of business cycles hinges on price movements; Aftalion[23] explains the rhythm of production by the rhythm of prices. Veblen states that "crises, depressions, hard times, dull times, brisk times, periods of speculative advance, eras of prosperity, are primarily phenomena of business; they are, in their origin and primary incidence, phenomena of price disturbance, either of decline or advance."[24] Brookmire says: "A comparison of a 'barometer chart' of commodity prices with similar charts of all other business factors leads me to believe that in a well-constructed index of the general level of prices we have one of the best single barometers obtainable."[25]

The reliability of seven index numbers of prices as business barometers has been tested by W. C. Mitchell for the period 1890-

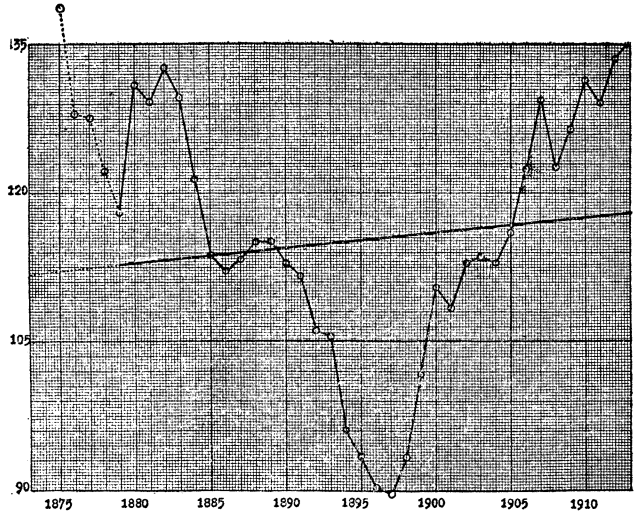

FIGURE 3. - Index numbers of general prices and secular trend.
Equation of the line of trend, y=0.1473x+113.87. Origin at 1879.

21 C. A. Juglar, *A Brief History of Panics in the United States,* English translation, by D. W. Thom, p. 2.

22 W. C. Mitchell, *Business Cycles,* pp. 570-578.

23 A. Aftalion, *Les Crises périodiques de Surproduction,* vol. II, pp. 397-411.

24 T. Veblen, *The Theory of Business Enterprise,* p. 180.

25 J. H. Brookmire, "Financial Forecasting," *Moody's Magazine,* vol. XVI, p. 159.

1913.[26] In twelve of twenty-three cases of changes from year to year all the indices agree as to the direction of the change. For the remaining eleven years Bradstreet's index makes the best showing as a barometer; but the index of the Bureau of Labor Statistics proves to be satisfactory, showing but two cases of direct disagreement with changes in business conditions—in 1895 and 1903. For the period 1879-1889 the Aldrich series is the only one available.

Figure 3 shows the first approximation to the business barometer, the Aldrich and Labor Bureau indices of wholesale prices adjusted to make a continuous series. The secular trend, indicated by the straight line of Figure 3, was determined both by the method of moments and the method of least squares, the results checking exactly.[27] In the present investigation of business cycles we are interested in the deviations of the annual figures from the secular trend or what we have termed the "cycles." The difference between the deviation for one year and that for the preceding year, it will be remembered, is the "first difference." The cycles and first differences of prices appear, respectively, in Figures 6 and 7. These series constitute the standard adopted with which to compare the other series under examination.

IV. Illustration of Method Used

The method of treating the various series of statistics is uni-

[26] Bulletin of the United States Bureau of Labor, No. 173, *Index Numbers of Wholesale Prices in the United States and Foreign Countries*, p. 111.

[27] The method of least squares was applied by correlating prices (or other series) with time measured from 1879, obtaining the equation of the line of regression (the secular trend) by use of the formulas

$$m = r\frac{\sigma_y}{\sigma_x};\ b = \bar{y} - m\bar{x};\ y = mx + b$$

where r = coefficient of correlation with time
σ = standard deviation
$\bar{x}$ and $\bar{y}$ = arithmetic averages of the two series

The method of moments was applied by solving the following simultaneous equations:

$$\Sigma y = m\Sigma x + 35b$$
$$\Sigma xy = m\Sigma x^2 + \Sigma xb$$

for m and b and substituting the values found in $y = mx + b$ to obtain the line of secular trend. Both methods were used and gave identical results in some fifteen cases. In the remaining cases the simpler method of moments alone was used.

form and will be explained in detail for the first series examined by the writer, bank clearings.

Following Fisher,[28] outside clearings were given a weight of 5 and combined with New York clearings. The graph is presented in Figure 4. The secular trend was computed by the method of

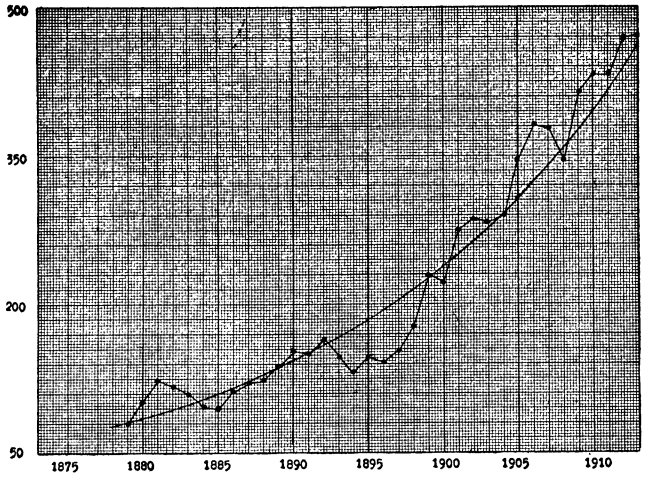

FIGURE 4. - New York clearings plus five times outside clearings, 1879-1913, and secular trend.

Equation of the line of trend, $y = 80.63\ (1.0536)^x$. Origin at 1879.

moments, using the compound interest law, $y = BC^x$ (see the smooth curve of Figure 4). The cycles of clearings are the deviations of the original figures from the secular trend thus found. The Pearsonian coefficients of correlation between the cycles of clearings and cycles of wholesale prices were computed.[29] The coefficients are (see Table 5): for prices preceding clearings by one year, +.575; concurrent, +.758; one-year lag, +.818; two-year lag, +.688; three-year lag, +.587. These coefficients indicate a high degree of correlation between the two series, the

[28] See *Purchasing Power of Money*, p. 447. Even though outside clearings are as fully reported as New York clearings, as Prof. B. M. Anderson contends, the weighting is justified in the present study on the ground that the outside clearings more strongly reflect conditions of industry rather than speculation; the contrary appears to be true of New York clearings.

[29] In the Pearsonian system +1 represents perfect direct correlation, —1 represents perfect inverse correlation, and 0 represents lack of correlation between the paired items. In the present study a coefficient of .45 may be considered significant, a coefficient of .60 high, and one of .75 or .80 very high. Just as length, weight, or heat must be "sensed" by experience so must the

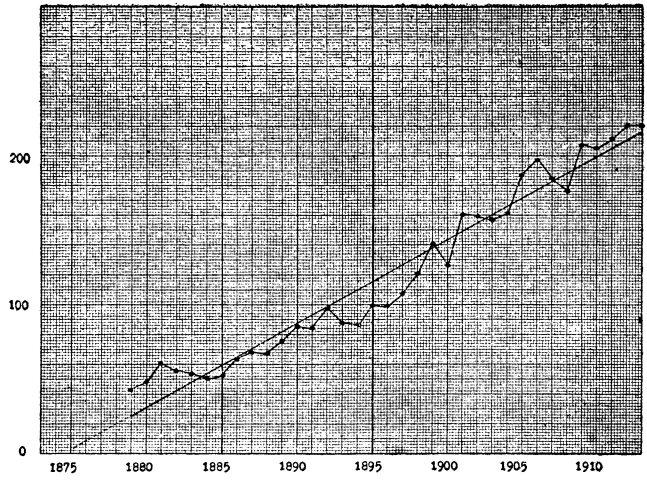

FIGURE 5 - Relative New York clearings plus five times outside clearings divided by relative wholesale prices, 1879-1913, or corrected clearing index, and secular trend Equation of line of trend, $y = 5.593 + 25\ 13$ Origin at 1879

maximum occurring for clearings of one year paired with prices of the following year. Further, the series of coefficients has a characteristic conformation, decreasing on either side of the maximum.

There are three elements entering into clearings: first, physical volume of goods exchanged; second, prices of those goods; third, the element due to the inclusion of credit instruments originating with loans and speculations. In order to eliminate the

meaning of the correlation coefficient. For purpose of comparison the following table is given:

Selected coefficients of correlation in man.

Right and left femur	.96
Femur and humerus	.84 to .87
Stature and femur	.80 to .81
Humerus and radius	.74 to .84
Weight and length of new-born male infants	.644 ± .012
Weight and stature of Cambridge (Eng.) male students	.486 ± .016
Clavicle and humerus	.44 to .63
Forearm and stature	.37
Breadth of head and ability, adults	.045 ± .032

The reliability of a coefficient depends not only upon its size but upon the number of items from which it is computed. The following table of probable errors is based upon 35 pairs of items of individual measurements and the assumption of normal distribution:

.95 ± .011	.75 ± .050	.55 ± .079	.35 ± .099	.15 ± .111
.90 ± .022	.70 ± .058	.50 ± .085	.30 ± .103	.10 ± .112
.85 ± .031	.65 ± .066	.45 ± .090	.25 ± .106	.05 ± .113
.80 ± .041	.60 ± .073	.40 ± .095	.20 ± .109	0 ± .113

influence of the price element, which would tend to give spurious correlation between clearings and wholesale prices of the same year, clearings were reduced to index numbers and divided by the concurrent items of the wholesale price series. The irregular graph in Figure 5 is the corrected clearing index; the straight line is the secular trend. The same straight line was found by two methods—moments and least squares. The cycles of corrected clearings and prices are shown together in Figure 6.

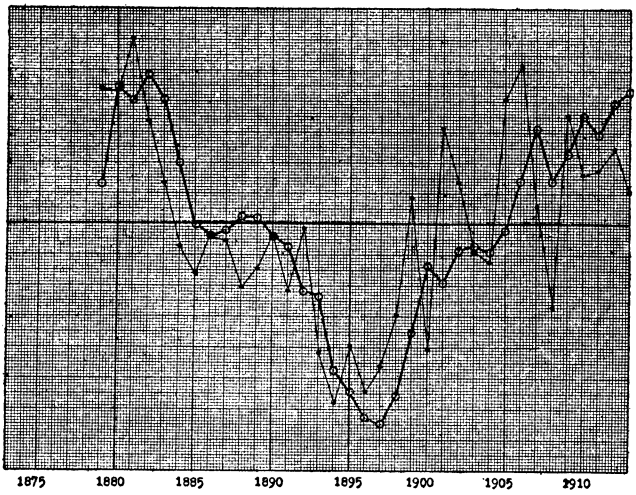

FIGURE 6. - Cycles of corrected clearing index (light line) and of wholesale prices (heavy line), 1879-1913. The horizontal line represents the secular trends.

Computing the coefficients of correlation for these cycles we have (see Table 3) concurrent, +.715; one-year lag in prices, +.852; two-year lag in prices, +.749. Thus, the lag of one year in prices is more pronounced when correlated with the corrected clearing index (price element eliminated) than with the clearing index. As would be expected, the coefficient for concurrent pairs is smaller and for a lag of two years is larger.

As a check upon the conclusion that cycles of clearings forecast cycles of wholesale prices by one year, the coefficients of correlation between first differences or annual changes of the two series were computed. The coefficients are (see Table 4): concurrent, +.039; one-year lag in prices, +.661; two-year lag, —.030. The conclusion is remarkably confirmed. Figure 7 presents the first differences of corrected clearings and prices graph-

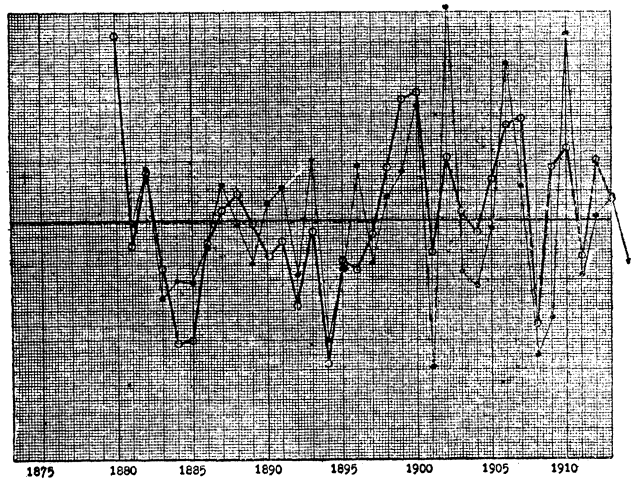

FIGURE 7. - First differences of corrected clearing index (light line) and of wholesale prices (heavy line), 1879-1913, the former shifted one year to the right.

ically; the graph representing clearings (light line) is shifted one year to the right in order to test the correspondence of fluctuations with those of prices.

It will be remembered that both Babson and Brookmire use bank clearings and prices together as elements of their business barometers. The analysis just made indicates that these series should not be so combined, since a movement in clearings forecasts a movement in prices by approximately one year.[30]

V. Construction of a Business Barometer

Applying the same method as that just described to the other series we are enabled to sort them into ones which have fluctuations concurrent with prices and ones which precede or lag behind prices. The series listed in Tables 1 and 2 fluctuate concurrently with prices and hence should enter the business barometer. The series listed in Tables 3, 5, and 7 have cycles preceding or lagging behind prices and hence should be excluded from the business barometer.

30 The conclusion here stated—that fluctuations in clearings precede fluctuations in industrial conditions (as indicated by general prices)—is confirmed by that of N. J. Silberling (see "The Mystery of Clearings" in the *Annalist* for Aug. 14, 1916). He has found that both New York and outside clearings reflect stock speculation. I have found stock speculation, volume of exchanges and prices, anticipates fluctuations in industry by approximately a year.

TABLE 1.—*Coefficients of correlation between cycles of relative wholesale prices and cycles of series entering into the business barometer, 1879-1913.*

Series correlated with relative wholesale prices:	Coefficients of correlation Prices precede (−) or lag behind (+) by:						
	−2 yr.	−1 yr.	0 yr.	+1 yr.	+2 yr.	+3 yr.	+4 yr.
	+	+	+	+	+	+	+
Gross receipts of railroads	.847	.917	.945	.856	.748	.637	—
Net earnings of railroads	.690	.763	.862	.839	.803	.811	—
Coal produced	.787	.865	.931	.880	.795	.731	.630
Exports from the U. S.	.547	.671	.783	.786	.772	.328	—
Imports into the U. S.	.796	.796	.861	.754	.578	.445	—
Pig-iron produced	—	—	.756	.738	.631	.617	.528
Price of pig-iron	.406	.558	.763	.739	.637	.576	—
Immigration[1]	.606	.718	.789	.626	.494	—	—
Relative wholesale prices	.811	.923	1.000	.923	.811	.691	.548

[1] Fiscal year. Calendar year for all other series.

TABLE 2.—*Coefficients of correlation between the first differences of relative wholesale price cycles and first differences of cycles entering into the business barometer, 1879-1913.*

Series correlated with relative wholesale prices:	Coefficients of correlation		
	Prices 1 year previous	Prices concurrent	Prices 1 year lag
Gross receipts of railroads	+ .273	+ .660	+ .074
Net earnings of railroads	− .095	+ .546	+ .177
Coal produced	. . .	+ .545	+ .037
Exports from the U. S.	. . .	+ .456	+ .111
Imports from the U. S.	− .261	+ .621	+ .213
Pig-iron produced	− .314	+ .408	+ .212
Price of pig-iron	− .221	+ .713	+ .246
Immigration	+ .170	+ .615	+ .046
Relative wholesale prices	+ .155	+ 1 000	+ .155

TABLE 3.—*Coefficients of correlation between cycles of relative wholesale prices and cycles of the series entering into the one-year forecaster, 1879-1913.*

Series correlated with relative wholesale prices:	Coefficients of correlation Prices precede (−) or lag behind (+) by:					
	−2 yr.	−1 yr.	0 yr.	+1 yr.	+2 yr.	+3 yr.
Shares sold on New York Stock Exchange[1]	. . .	+ .133	+ .244	+ .470	+ .491	+ .508
Average price of shares sold on New York Stock Exchange	+ .548	+ .622	+ .741	+ .826	+ .754	+ .620
Corrected clearing index	. . .	. .	+ .715	+ .852	+ .749	. . .
New railroad mileage	. . .	+ .436	+ .566	+ .572	+ .418	+ .248
Per cent of business failures	. . .	− .412	− .628	− .653	+ .505	− .251

[1] Coefficients for 4, 5, and 6 year lag are, respectively, + .525, + .520 and + .551.

TABLE 4.—*Coefficients of correlation between first differences of cycles of relative wholesale prices and of cycles entering into the one-year forecaster, 1879-1913.*

Series correlated with relative wholesale prices:	Coefficients of correlation Prices precede (—) or lag behind (+) by 0 yr.	+ 1 yr.	+ 2 yr.
Number of shares sold on New York Stock Exchange .	— .033	+ .518	+ .013
Average price of shares sold on New York Stock Exchange .	+ .094	+ .571	+ .060
Corrected clearing index . .	+ .039	+ .661	— .030
New railroad mileage	+ .208	+ .463	+ .077
Percentage of business failures	— .304	— .615	+ .029

TABLE 5.—*Coefficients of correlation between cycles of relative wholesale prices and cycles of miscellaneous series, 1879-1913.*

Series correlated with relative wholesale prices:	Coefficients of correlation Prices precede (—) or lag behind (+) by —2 yr.	—1 yr.	0 yr.	+1 yr.	+2 yr.	+3 yr.	+4 yr.	+5 yr.	+6 yr.
Liabilities of business failures . .	. . .	. . .	— .030	— .347	— .403	— .227	— .151	— .075	. . .
Imports plus exports	. . .	. .	+ .887	+ .854	+ .760	. . .	. . .	. .	. . .
Clearing index . .	. .	+ .575	+ .758	+ .818	+ .688	+ .587	. .	. .	. . .
Balance of trade .	— .238	— .062	— .017	+ .154	+ .337	+ .417	+ .521	+ .594	+ .586
Indices of crop yield: Annual figures .	+ .083	— .041	+ .093	+ .246	+ .326	+ .466	+ .531	+ .491	+ .328
Imports ÷ Relative wholesale prices .	. . .	. . .	+ .880	+ .785	+ .589	. . .	. . .	. . .	. . .

TABLE 6.—*Coefficients of correlation between first differences of cycles of wholesale prices and of miscellaneous series, 1879-1913.*

Series correlated with relative wholesale prices:	Coefficients of correlation Prices lag behind (+) by 0 yr.	+1 yr.	+2 yr.	+3 yr.	+4 yr.	+5 yr.
Liabilities of business failures .	+ .182	— .465	— .051	. . .	. . .	. . .
Imports plus exports	+ .670	+ .217	+ .151	. . .	. . .	. . .
Indices of crop yield: Annual figures	. . .	. . .	. . .	+ .019	+ .193	+ .296

Before the nine series of Table 1 were averaged they were reduced to relative numbers by dividing each item by the standard deviation of the series. Using the standard deviations, as the units, results in series which, logically, may be averaged since the series with wide fluctuations have high standard deviations and those with narrow fluctuations have small standard deviations. The process of dividing each series by the standard deviation of that series is equivalent to expressing each series in terms of its standard deviation as a unit; the series of relatives resulting all

TABLE 7.—*Coefficients of correlation between cycles of relative wholesale prices and cycles of certain financial series.*[1]

Series correlated with relative wholesale prices:	Coefficients of correlation Prices precede (—) or lag behind (+) by							
	—2 yr.	—1 yr.	0 yr.	+1 yr.	+2 yr.	+ 3yr.	+4 yr.	+5 yr.
Ratio of loans to resources of banks	. . .	. . .	—.280	—.494	—.770	—.687	—.705	—.670
Ratio of cash to deposits in banks	—0.42	—.177	—.316	—.320	—.285	—.374	. . .	. . .
Surplus reserves of New York Assoc. Banks . .	—.178	—.299	—.510	—.481	—.351	—.291	. . .	. . .
Average rates of interest on: Ten railroad bonds,	+.573	+.522	+.364	+.052	—.069	. . .	. . .	. . .
4-6 mos. comm. paper, .	+.152	+.216	+.410	+.147	+.032	. . .	. . .	. . .
60-90 days " " .	+.236	+.314	+.505	+.272	+.193	. . .	. . .	. . .
Call loans	+.034	+.138	+.434	+.435	+.278	. . .	. . .	. . .
(All in N. Y. market)								

[1] The first three series listed are for the period, 1879-1913; the average rates of interest are taken from Mitchell's *Business Cycles* and are for the period, 1890-1911.

TABLE 8.—*Coefficients of correlation between first differences of cycles of relative wholesale prices and of certain financial series.*[1]

Series correlated with relative wholesale prices:	Coefficients of correlation Prices precede (—) or lag behind (+) by			
	— 1 yr.	0 yr.	+ 1 yr.	+ 2 yr.
Ratio of loans to resources . .	. . .	+.451	—.179	—.221
Ratio of cash to deposits . . .	. . .	—.304	—.068	—.136
Surplus reserves of N. Y. banks	+.189	—.498	—.212	. . .
Average rates of interest on:				
Ten railroad bonds	+.221	+.240	—.584	+.051
4-6 mos. comm. paper . . .	—.116	+.528	—.219	—.120
60-90 days " " . . .	—.094	+.527	—.232	—.060
Call loans	—.204	+.498	+.186	—.226

[1] The first three series listed are for the period 1879-1913; the average rates of interest are taken from Mitchell's *Business Cycles* and are for the period, 1890-1911.

have the same standard deviation. The process gives the same weight, as nearly as may be, to the series averaged. The relative numbers thus obtained, together with their average, are given in Table 10.

Objection has been offered (by Irving Fisher, for instance) to the application of the Pearsonian coefficient of correlation to time series on the ground that the order of the items has no influence on the size of the coefficient. In the present application, involving as it does the computation of several coefficients for each series and prices, the order of the items determines the various associated

TABLE 9.—*Coefficients of correlation, first, between cycles of the business barometer and cycles of various series and, second, between first differences of the business barometer cycles and of cycles of various series, 1879-1913.*

Series correlated with the business barometer:	Lag of the bus. bar.	Coefficients of correlation	
		Cycles	1st diffs.
Gross receipts of railroads	0 yr.	+ .939	+ .795
Net earnings of railroads	"	+ .885	+ .781
Coal produced	"	+ .951	+ .847
Exports from the U. S.	"	+ .800	+ .516
Imports into the U. S.	"	+ .877	+ .830
Pig-iron produced	"	+ .865	+ .828
Price of pig-iron	"	+ .785	+ .696
Immigration	"	+ .835	+ .778
Relative wholesale prices	"	+ .945	.782
Average of non-price series[1]	"	. . .	+ .857
Ratio of loans to resources of banks[2]	0 yr.	. . .	+ .509
Ratio of cash to deposits in banks	"	— .388	— .441
Surplus reserves of N. Y. assoc. banks	"	— .600	— .724
Shares sold on N. Y. stock exchange	1 yr.	+ .400	+ .521
Average price of shares sold on exchange	"	+ .766	+ .504
Corrected clearing index	"	+ .795	+ .524
New railroad mileage	"	+ .525	+ .224
Percentage business failures	"	— .775	— .308
Average of 5 preceding series	"	+ .860	+ .510
Average of corrected clearings and price of shares sold	"	+ .800	+ .545
Weighted index numbers of the yield per acre of nine leading crops, three-year averages	4 yr.	+ .655	. . .

[1] Gross receipts and net earnings of railroads, coal and pig-iron produced, and immigration.

[2] The coefficient of correlation between the cycles for a two-year lag in the business barometer is — .602.

TABLE 1

Year	1 Wholesale prices	2 Gross receipts of railroads	3 Net earnings of railroad	4 Coal produced	5 Exports from the U. S.	6 Imports into the U.S.	7 Pig-iron produced	8 Price of pig-iron	9 Immigrati
1879	+ .42	+ .99	+ .92	+ 1.21	+ 1.59	+ .39	+ 1.04	+ .22	— .62
1880	+ 1.40	+ 1.03	+ 1.17	+ .96	+ 1.94	+ 1.28	+ 1.15	+ 2.18	+ .54
1881	+ 1.27	+ 1.12	+ 1.12	+ .98	+ 1.44	+ .94	+ .97	+ 1.29	+ 1.41
1882	+ 1.53	+ 1.07	+ .96	+ 1.07	+ .90	+ 1.22	+ .87	+ 1.51	+ 1.87
1883	+ 1.28	+ 1.03	+ .94	+ 1.01	+ .80	+ .72	+ .63	+ .59	+ .96
1884	+ .63	+ .52	+ .34	+ .79	+ .35	+ .22	+ .17	— .11	+ .51
1885	.00	+ .17	+ .10	+ .22	— .20	— .17	— .14	— .56	— .12
1886	— .12	+ .13	+ .22	— .03	— .25	+ .06	+ .17	— .34	— .47
1887	— .06	+ .26	+ .41	+ .03	— .55	+ .17	+ .14	+ .34	+ .15
1888	+ .08	+ .04	— .26	+ .14	— .90	+ .11	— .10	— .20	+ .33
1889	+ .06	— .09	— .23	— .39	— .40	+ .22	.00	— .45	— .21
1890	— .13	+ .04	— .18	— .31	— .50	+ .33	+ .31	— .25	— .24
1891	— .24	— .13	— .32	— .39	— .20	+ .22	— .28	— .45	+ .15
1892	— .69	— .21	— .53	— .48	— .55	+ .11	— .24	— .90	+ .36
1893	— .74	— .34	— .70	— .73	— 1.14	— .39	— 1.25	— 1.20	— .26
1894	— 1.50	— 1.24	— 1.44	— 1.38	— 1.59	— 1.11	— 1.67	— 1.68	— 1.18
1895	— 1.71	— 1.46	— 1.62	— 1.18	— 1.79	— .61	— 1.00	— 1.51	— 1.41
1896	— 1.97	— 1.59	— 1.75	— 1.55	— 1.14	— 1.44	— 1.53	— 1.51	— 1.20
1897	— 2.04	— 1.89	— 1.86	— 1.66	— .90	— 1.28	— 1.42	— 1.74	— 1.78
1898	— 1.76	— 1.67	— 1.53	— 1.52	— .35	— 2.06	— .97	— 1.79	— 1.87
1899	— 1 11	— 1.59	— 1.05	— 1.01	— .55	— 1.28	— .63	+ .39	— 1.57
1900	— .43	— 1.20	— .86	— .95	+ .30	— 1.28	— .83	+ .62	— 1.04
1901	— .60	— 1.03	— .64	— .70	.00	— 1.17	— .38	— .50	— .94
1902	— .27	— .86	— .39	— .84	— .75	— .83	.00	+ 1.32	— .30
1903	— .22	— .89	— .23	+ .20	— .40	— .83	— .17	+ .70	+ .55
1904	— .28	— .89	+ .10	— .28	— .80	— .78	— .97	— .45	+ .28
1905	— .06	— .13	+ .42	+ .42	— .10	— .17	+ 1.01	+ .22	+ 1.15
1906	+ .44	+ .60	+ 1.48	+ .62	+ .50	+ .44	+ 1.53	+ 1.15	+ 1.41
1907	+ .99	+ 1.37	+ 1.76	+ 1.91	+ .90	+ .89	+ 1.42	+ 1.99	+ 2.15
1908	+ .44	+ .26	+ .11	— .06	— .20	— .94	— 2.29	+ .31	— .17
1909	+ .73	+ .39	+ 1.51	+ .67	— .60	+ .89	+ .87	+ .36	— .38
1910	+ 1.11	+ 1.33	+ 2.09	+ 1.38	— .05	+ 1.17	+ 1.15	+ .28	+ .83
1911	+ .92	+ .99	.00	+ .87	+ .80	+ .83	— .42	— .14	+ .03
1912	+ 1.25	+ 1.03	— .31	+ 1.49	+ 2.09	+ 2.28	+ 1.42	+ .14	— .22
1913	+ 1.36	+ 2.02	+ .43	+ 2.05	+ 2.34	+ 1.95	+ 1.60	+ .31	+ 1.30

[1] In hundred millions, not in terms of standard deviation.
[2] Signs reversed.
[3] Fiscal year ending June 30.

TABLE 10.—*Cycles of various series in terms of the respective standard deviations as units, toge*

rts U.S.	7 Pig-iron produced	8 Price of pig-iron	9 Immigration[3]	10 Shares sold on N. Y. Exchange	11 Average price of shares sold on N.Y.Exch.	12 Clearing index[1]	13 Corrected clearing index	14 New railroad mileage	15 Per cent of business failures[2]	16 Liabil of bus failu
39	+1.04	+ .22	— .62	+ .14	+ .28	— 9	+1.41	— .82	+ .45	—
28	+1.15	+2.18	+ .54	+ .54	+1.90	+ 147	+1.38	+ .04	+2.26	—1.
94	+ .97	+1.29	+1.41	+ .82	+2.02	+ 340	+1.94	+1.42	+1.75	—
22	+ .87	+1.51	+1.87	+ .76	+1.11	+ 228	+1.08	+2.24	+1.13	—
72	+ .63	+ .59	+ .96	+ .33	+ .73	+ 99	+ .43	+ .17	— .28	+
22	+ .17	— .11	+ .51	+ .23	+ .21	— 72	— .24	— .99	—1.13	+1.
17	— .14	— .56	— .12	+ .08	+ .37	—151	— .52	—1.34	— .85	—
06	+ .17	— .34	— .47	+ .19	+ .43	— 38	— .13	+ .91	— .06	—
17	+ .14	+ .34	+ .15	— .19	— .35	— 1	— .18	+3.06	+ .56	+
11	— .10	— .20	+ .33	— .64	— .30	— 49	— .65	+ .52	— .17	—
22	.00	— .45	— .21	— .58	— .65	+ 26	— .47	— .17	— .28	+
33	+ .31	— .25	— .24	— .68	— .91	+ 101	— .11	— .04	0	+
22	— .28	— .45	+ .15	— .78	—1.50	— 6	— .70	— .60	— .51	+
11	— .24	— .90	+ .36	— .52	— .76	+ 65	— .05	— .39	+ .51	—
39	—1.25	—1.20	— .26	— .70	—1.36	— 193	—1.35	—1.25	—2.26	+3.
11	—1.67	—1.68	—1.18	—1.38	— .97	— 433	—1.87	—1.38	—1.53	+
61	—1.00	—1.51	—1.41	—1.11	—1.66	— 360	—1.28	—1.42	—1.13	+
44	—1.53	—1.51	—1.20	—1.40	—1.14	— 521	—1.75	—1.34	—2.32	+1.
28	—1.42	—1.74	—1.78	—1.05	—1.04	— 498	—1.49	—1.25	—1.58	—
06	— .97	—1.79	—1.87	— .43	— .39	— 374	— .96	—1.03	— .73	—
28	— .63	+ .39	—1.57	+ .74	+ .28	+ 27	+ .28	— .22	+ .62	—1.
28	— .83	+ .62	—1.04	— .08	—1.18	— 164	—1.31	— .43	+ .28	—
17	— .38	— .50	— .94	+2.35	+ .03	+ 259	+ .99	+ .09	+ .23	—1.
83	.00	+1.32	— .30	+ .76	.00	+ 221	+ .42	0	+ .34	—
83	— .17	+ .70	+ .55	+ .16	—1.08	+ 55	— .30	+ .13	+ .68	—
78	— .97	— .45	+ .28	+ .60	—1.69	— 24	— .40	+ .47	+ .34	—
17	+1.01	+ .22	+1.15	+2.00	+ .57	+ 379	+1.30	+ .43	+ .68	—1.
44	+1.53	+1.15	+1.41	+2.35	+1.37	+ 587	+1.66	+ .69	+1.07	—1.
89	+1.42	+1.99	+2.15	+ .56	+ .06	+ 377	+ .19	+ .82	+ .79	+
94	—2.29	+ .31	— .17	+ .50	+ .01	— 126	— .88	+ .17	— .62	+
89	+ .87	+ .36	— .38	+ .80	+1.37	+ 373	+1.13	+1.25	+ .62	—
17	+1.15	+ .28	+ .83	— .27	+1.05	+ 352	+ .52	+ .22	+ .73	+
83	— .42	— .14	+ .03	—1.07	+ .85	+ 148	+ .56	+ .13	+ .56	+
28	+1.42	+ .14	— .22	—1.05	+ .97	+ 279	+ .79	— .04	— .11	+
95	+1.60	+ .31	+1.30	—2.06	+ .62	+ 80	+ .34	+ .04	— .23	+1.

pective standard deviations as units, together with the business barometer and one-year forecasters.

13 rected aring dex	14 New railroad mileage	15 Per cent of business failures[2]	16 Liabilities of business failures	17 Balance of trade	18 Indices of crop yield	19 Ratio of loans to resources	20 Ratio of cash to deposits	21 Surplus reserves of N. Y. banks	22 Interest rate on 10 railroad bonds	Inter or month
1.41	— .82	+ .45	— .52	+ 1.70	+ 2.06	— 2.08	— .83	— .56	. . .	.
1.38	+ .04	+ 2.26	— 1.16	+ 1.17	+ 1.29	— 1.46	+ 1.00	— .64	. . .	.
1.94	+ 1.42	+ 1.75	— .92	+ .84	— 1.80	— 1.40	— .51	— .81	. . .	.
1.08	+ 2.24	+ 1.13	— .56	— .31	+ .39	— .88	— 1.48	— .91	. . .	.
.43	+ .17	— .28	+ .73	+ .22	0	— .20	— .57	— .86	. . .	.
.24	— .99	— 1.13	+ 1.69	+ .19	+ .51	— .07	— .43	+ .53	. . .	.
.52	— 1.34	— .85	— .26	— .07	.00	— .80	+ 2.12	+ 2.81	. . .	.
.13	+ .91	— .06	— .45	— .54	— .64	+ .14	+ .28	— .08	. . .	.
.18	+ 3.06	+ .56	+ .51	— .98	— 1.29	+ .84	+ .49	— .60	. . .	.
.65	+ .52	— .17	— .36	— 1.36	+ .13	+ 1.20	+ .56	+ .12	. . .	.
.47	— .17	— .28	+ .07	— .84	+ .51	+ 1.40	+ .85	— .72	. . .	.
.11	— .04	0	+ .81	— 1.12	— 1.41	+ 2.04	— .34	— 1.04	+ .44	+
.70	— .60	— .51	+ .77	— .48	+ 1.03	+ 1.98	— .54	— .36	+ 1.18	+
.05	— .39	+ .51	— .69	— .92	— .39	+ 1.78	+ .66	— .08	+ .44	—
1.35	— 1.25	— 2.26	+ 3.63	— 1.01	— 1.16	+ 2.04	— .52	+ .42	+ 1.10	+
1.87	— 1.38	— 1.53	+ .34	— .78	— 1.54	+ .52	+ 2.96	+ 2.46	+ .57	—
1.28	— 1.42	— 1.13	+ .30	— 1.78	.00	+ .52	+ 1.27	+ .95	+ .22	—
1.75	— 1.34	— 2.32	+ 1.27	+ .20	— .13	+ .56	— .42	+ .37	+ .66	+
1.49	— 1.25	— 1.58	— .11	+ .33	— .13	— .23	+ 1.07	+ 1.78	+ .13	—
.96	— 1.03	— .73	— .58	+ 2.04	+ 1.03	— .20	+ .98	+ 1.15	— .44	—
.28	— .22	+ .62	— 1.37	+ .92	+ .13	— .78	— .17	— .04	— 1.36	—
1.31	— .43	+ .28	— .52	+ 2.01	.00	— .75	— .35	— .24	— 1.27	—
.99	+ .09	+ .23	— 1.03	+ 1.44	— 2.06	— .91	— .97	— .38	— 1.80	—
.42	0	+ .34	— .97	— .03	+ 1.16	— .36	— 1.05	— .71	— 1.71	+
.30	+ .13	+ .68	— .32	+ .53	+ .13	— .28	— 1.24	— .63	— .70	+
.40	+ .47	+ .34	— .56	— .10	+ 1.03	— .81	— .26	+ .74	— .70	—
1.30	+ .43	+ .68	— 1.37	+ .01	+ 1.29	— .56	— 1.17	— .78	— 1.01	—
1.66	+ .69	+ 1.07	— 1.09	+ .10	+ 1.54	— .21	— 1.45	— 1.05	— .31	+ 1
.19	+ .82	+ .79	+ .34	+ .14	— .13	— .14	— 1.15	— 1.72	+ 1 10	+ 1
.88	+ .17	— .62	+ .77	+ .97	+ .13	— .97	+ .99	+ 1.77	+ 1.01	—
1.13	+ 1.25	+ .62	— .52	— 1.82	.00	— .47	+ .79	— .35	+ .48	—
.52	+ .22	+ .73	+ .32	— 1.59	.00	+ .11	— .02	+ .03	+ 1.23	+
.56	+ .13	+ .56	+ .07	+ .09	— 1.29	— .09	+ .52	+ .49	+ 1.49	—
.79	— .04	— .11	+ .26	+ .12	+ 1.16	+ .09	+ .17	— .52	. . .	. .
.34	+ .04	— .23	+ 1.54	+ .78	— 1.16	+ .40	.00	— .47	. . .	. .

recasters.

20 Ratio of cash to deposits	21 Surplus reserves of N. Y. banks	22 Interest rate on 10 railroad bonds	23 Interest rate on 4-6 months' paper	24 Interest rate on 60-90 dy. paper	25 Interest rate on call loans	Average of series 1 to 9 inclusive	Average of series 2, 3, 4, 7 and 9	Average of series 11 and 13	Average of series 10, 11, 13, 14 and 15
— .83	— .56	. . .	. . .	. . .	. . .	+ .684	+ .708	+ .85	+ .292
+ 1.00	— .64	. . .	. . .	. . .	. . .	+ 1.294	+ .970	+ 1.64	+ 1.224
— .51	— .81	. . .	. . .	. . .	. . .	+ 1.171	+ 1.120	+ 1.98	+ 1.590
— 1.48	— .91	. . .	. . .	. . .	. . .	+ 1.222	+ 1.168	+ 1.10	+ 1.264
— .57	— .86	. . .	. . .	. . .	. . .	+ .884	+ .914	+ 1.08	+ .276
— .43	+ .53	. . .	. . .	. . .	. . .	+ .380	+ .466	— .02	— .384
+ 2.12	+ 2.81	. . .	. . .	. . .	. . .	— .078	+ .046	— .08	— .452
+ .28	— .08	. . .	. . .	. . .	. . .	— .070	+ .004	+ .15	+ .268
+ .49	— .60	. . .	. . .	. . .	. . .	+ .008	+ .034	— .27	+ .580
+ .56	+ .12	. . .	. . .	. . .	. . .	— .084	+ 030	— .48	— .248
+ .85	— .72	. . .	. . .	. . .	. . .	— .166	— .184	— .560	— .430
— .34	— 1.04	+ .44	+ .81	+ .95	+ 1 46	— .103	— .076	— .51	— .348
— .54	— .36	+ 1.18	+ .33	+ .72	— .03	— .182	— .194	— 1.10	— .818
+ .66	— .08	+ .44	— 1.19	— .72	— .28	— .348	— .220	— .41	— .242
— .52	+ .42	+ 1.10	+ 2.09	+ 2.26	+ .67	— .750	— .656	— 1 36	— 1.384
+ 2.96	+ 2.46	+ .57	— 1 26	— 1.75	— 1.52	— 1.421	— 1.382	— 1.42	— 1.426
+ 1.27	+ .95	+ .22	— .46	— 1.12	— 1.04	— 1.366	— 1.334	— 1.47	— 1.320
— .42	+ .37	+ .66	+ 1.47	+ 1.13	+ .42	— 1.520	— 1.524	— 1 45	— 1.590
+ 1.07	+ 1.78	+ .13	— 1.74	— 1.17	— 1.10	— 1.619	— 1.722	— 1.27	— 1.282
+ .98	+ 1.15	— .44	— .81	— .89	— .87	— 1.502	— 1.512	— .68	— .708
— .17	— .04	— 1.36	— .50	— .64	+ .91	— .933	— 1.170	+ .28	+ .340
— .35	— .24	— 1.27	— .09	— .29	— .40	— .630	— .976	— 1 25	— .544
— .97	— .38	— 1.80	— .44	— .43	+ .24	— .662	— .738	+ .51	+ .738
— 1.05	— .71	— 1.71	+ .13	+ .25	+ 1.01	— .324	— .478	+ .21	+ .304
— 1.24	— .63	— .70	+ .85	+ .84	+ .11	— .088	— .008	— .69	— .082
— .26	+ .74	— .70	— .60	— .40	— 1.15	— .397	— .252	— 1.05	— .136
— 1.17	— .78	— 1.01	— .46	— .28	+ .47	+ .307	+ .574	+ .94	+ .996
— 1.45	— 1.05	— .31	+ 1.14	+ 1.13	+ 1.73	+ .908	+ 1 128	+ 1.52	+ 1.428
— 1.15	— 1.72	+ 1 10	+ 1.67	+ 1.76	+ 2.24	+ 1.487	+ 1.722	+ .13	+ .484
+ .99	+ 1.77	+ 1.01	— .54	— .18	— 1.06	— .282	— .430	— .44	— .164
+ .79	— .35	+ .48	— .86	— .76	— .62	+ .493	+ .612	+ 1.25	+ 1.034
— .02	+ .03	+ 1.23	+ .71	+ .45	— .45	+ 1.032	+ 1 356	+ .79	+ .450
+ .52	+ .49	+ 1.49	— .64	— .58	— .71	+ .431	+ .294	+ .71	+ .206
+ .17	— .52	. . .	. . .	. . .	. . .	+ 1.019	+ .682	+ .88	+ .112
.00	— .47	. . .	. .	. .	. .	+ 1.484	+ 1.480	+ .48	— .258

pairs and hence the relative size of the coefficients of correlation between cycles. Also the sequence of the items in the series determines the first differences and hence the values of the coefficients based upon such first differences. The conclusion as to what series have concurrent fluctuations with prices and hence should enter the business barometer does not depend, so much, on the absolute size of the coefficients as upon their relative size, and conformation as to size when arranged according to lag. The series of coefficients between cycles of wholesale prices and wholesale prices with various degrees of lag offers a standard for comparison (see last line of Table 1). In every series of Table 1, except imports, the coefficients gradually increase, reaching a maximum for concurrent items, and then as gradually decrease. The conclusions

TABLE 11.—*Equations of lines of secular trend and standard deviation of cycles.*[1]

Series	Equation of line of secular trend	Standard deviation of cycles
1. Wholesale prices	$y = .1475x + 112.9$	12.7
2. Gross receipts of railroads	$y = 7.062x + 30.03$	23.3
3. Net earnings of railroads	$y = 19.58x + 141.7$	81.3
4. Coal produced	$y = 12.27x + 18.07$	35.6
5. Exports from the U. S.	$y = 4.626x + 44.94$	20.1
6. Imports into the U. S.	$y = 2.94x + 44.0$	18.0
7. Pig-iron produced	$y = 7.852x - 3.00$	28.8
8. Price of pig-iron	$y = -.1464x + 20.89$	3.6
9. Immigration (fiscal year)	$y = 17.31x + 318.2$	224.0
10. Shares sold on N. Y. Exchange	$y = 3.61x + 66.0$	51.5
11. Average price of shares on N. Y. Exchange	$y = 1.09x + 54.8$	7.2
12. Clearing index	$y = 80.63\ (1.0526)^x$	——
13. Corrected clearing index	$y = 5.60x + 25.0$	12.4
14. New railroad mileage	$y = -1.097x + 67.11$	23.2
15. Percent of business failures	$y = -.462x + 103.3$	17.7
16. Liabilities of business failures	$y = 1.905x + 126.1$	53.4
17. Balance of trade	$y = 16.807x + 9.34$	143.0
18. Index numbers of crop yield	$y = .432x + 95.25$	7.8
19. Ratio of loans to resources	$y = .0644x + 53.44$	3.1
20. Ratio of cash to deposits	$y = -.144x + 13.75$	1.1
21. Surplus reserves of N. Y. banks	$y = .2282x + 13.51$	11.8
22. Average rate of interest on: Ten railroad bonds	$y = -.0381x + 4.625$	.23
23. 4-6 mos. paper	$y = -.0556x + 6.32$	.70
24. 60-90 dy. paper	$y = -.00711x + 4.738$	.95
25. Call loans	$y = .012x + 3.462$	1.61

[1] Origin of line of secular trend at 1879 except for numbers 22 to 25 for which origin is at 1890. The standard deviations times the respective series of Table 10 will give the cycles in the original units.

TABLE 12.—*Coefficients of correlation between cycles and multiple differences, first to sixth, of business barometer and those of the series entering into the business barometer, 1879-1913.*
(Various degrees of lag)

Series correlated with business barometer:	Difference	Coefficients of correlation Business barometer precedes (—) or lags behind (+) by:						
		—3 yr.	—2 yr.	—1 yr.	0 yr.	+1 yr.	+2 yr.	+3yr.
Gross receipts of railroads	C	. . .	. . .	. . .	+.94	. . .	. . .	. . .
	1st	. . .	. . .	+.34	+.80	—.28	. . .	. . .
	2nd	. . .	. . .	+.08	+.74	—.64	. . .	. . .
	3rd	. . .	. . .	—.06	+.74	—.71	. . .	. . .
	4th	. . .	. . .	—.18	+.76	—.74	. . .	. . .
	5th	+.25	—.22	—.24	+.75	—.75	+.25	+.09
	6th	. . .	. . .	. . .	+.74	. . .	. . .	. . .
Net earnings of railroads	C	. . .	. . .	. . .	+.89	. . .	. . .	. . .
	1st	. . .	. . .	. . .	+.78	. . .	. . .	. . .
	5th	. . .	. . .	—.49	+.76	—.39	. . .	. . .
	6th	. . .	. . .	. . .	+.72	. . .	. . .	. . .
Coal produced	C	. . .	. . .	. . .	+.95	. . .	. . .	. . .
	1st	. . .	. . .	. . .	+.85	. . .	. . .	. . .
	5th	. . .	. . .	—.62	+.90	—.81	. . .	. . .
	6th	. . .	. . .	. . .	+.90	. . .	. . .	. . .
Exports from the U. S.	C	. . .	. . .	. . .	+.80	. . .	. . .	. . .
	1st	. . .	. . .	. . .	+.52	. . .	. . .	. . .
	5th	. . .	. . .	—.11	+.38	—.46	. . .	. . .
	6th	. . .	. . .	. . .	+.37	. . .	. . .	. . .
Imports into the U. S.	C	. . .	. . .	. . .	+.88	. . .	. . .	. . .
	1st	. . .	. . .	. . .	+.83	. . .	. . .	. . .
	5th	. . .	. . .	—.82	+.83	—.42	. . .	. . .
	6th	. . .	. . .	—.84	+.83	—.49	. . .	. . .
Pig-iron produced	C	. . .	. . .	. . .	+.87	. . .	. . .	. . .
	1st	. . .	. . .	. . .	+.83	. . .	. . .	. . .
	5th	. . .	. . .	—.83	+.87	—.36	. . .	. . .
	6th	. . .	. . .	—.86	+.86	—.43	. . .	. . .
Price of pig-iron	C	. . .	. . .	. . .	+.79	. . .	. . .	. . .
	1st	. . .	. . .	. . .	+.70	. . .	. . .	. . .
	5th	. . .	. . .	—.54	+.65	—.36	. . .	. . .
	6th	. . .	. . .	. . .	+.65	. . .	. . .	. . .
Immigration	C	. . .	. . .	. . .	+.84	. . .	. . .	. . .
	1st	. . .	. . .	. . .	+.78	. . .	. . .	. . .
	5th	. . .	. . .	—.36	+.82	—.85	. . .	. . .
	6th	. . .	. . .	. . .	+.81	. . .	. . .	. . .
Relative wholesale prices	C	. . .	. . .	. . .	+.95	. . .	. . .	. . .
	1st	. . .	. . .	+.20	+.78	—.03	. . .	. . .
	2nd	. . .	. . .	—.22	+.78	—.46	. . .	. . .
	3rd	. . .	. . .	—.35	+.78	—.57	. . .	. . .
	4th	. . .	. . .	—.40	+.76	—.59	. . .	. . .
	5th	+.12	—.01	—.42	+.74	—.58	+.15	+.09
	6th	. . .	. . .	. . .	+.71	. . .	. . .	. . .

derived from Table 1 are confirmed by Table 2, in which the maximum coefficients are more strongly set off from the neighboring values than in the former table. The coefficients for first differences of imports warrant the conclusion that imports fluctuate concurrently with prices.

It will be noticed that four of the nine series listed in Tables 1 and 2 are themselves price series: *i. e.*, exports from the United States, imports into the United States, price of pig-iron, and wholesale prices of commodities. An average of the non-price series—*i. e.*, gross receipts and net earnings of railroads, coal and pig-iron production, and immigration—was taken in order to compare the fluctuations with those of wholesale prices (see Figure 8). The correspondence is very great.

Figure 9 presents the cycles of the business barometer computed from the nine series of Table 1 (the dotted line) together with cycles of wholesale prices. Figure 10 presents the first differences of the two series.

The coefficients of correlation between the cycles of the various

TABLE 13.—*Probable errors of coefficients of correlation for multiple differences, first to sixth, with 35 items in the original series.*[1]

Coefficients of correlation	Order of difference					
	First	Second	Third	Fourth	Fifth	Sixth
	±	±	±	±	±	±
.95	.014	.015	.017	.019	.020	.021
.90	.027	.031	.034	.037	.039	.042
.85	.039	.045	.050	.054	.058	.061
.80	.051	.059	.065	.070	.075	.079
.75	.062	.071	.078	.085	.091	.096
.70	.072	.083	.091	.099	.106	.112
.65	.081	.094	.104	.112	.120	.127
.60	.090	.104	.115	.124	.132	.140
.55	.098	.113	.125	.135	.144	.153
.50	.106	.122	.134	.145	.155	.164
.45	.112	.130	.143	.155	.165	.175
.40	.118	.136	.151	.163	.174	.184
.35	.124	.142	.157	.170	.182	.193
.30	.128	.148	.163	.177	.188	.200
.25	.132	.152	.168	.182	.194	.206
.20	.135	.156	.172	.186	.199	.211
.15	.138	.159	.175	.190	.202	.214
.10	.139	.161	.177	.192	.205	.217
.05	.140	.162	.179	.194	.206	.219
.00	.140	.163	.179	.194	.207	.219

[1] Computed by the formula given by A. Ritchie-Scott in *Biometrika*, November 1915, p. 136, based on the work of O. Anderson, *ibid.*, November, 1914.

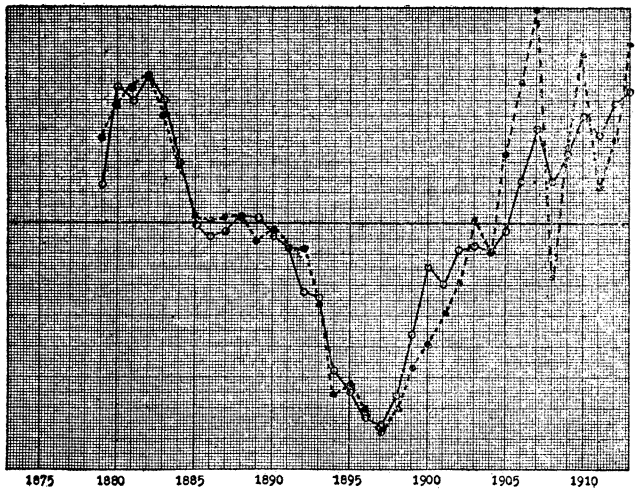

FIGURE 8. - Cycles of wholesale prices (solid line) and of the average of five non-price series: i.e., gross and net railroad earnings, coal and pig-iron production, and immigration (dotted line), 1879-1913.

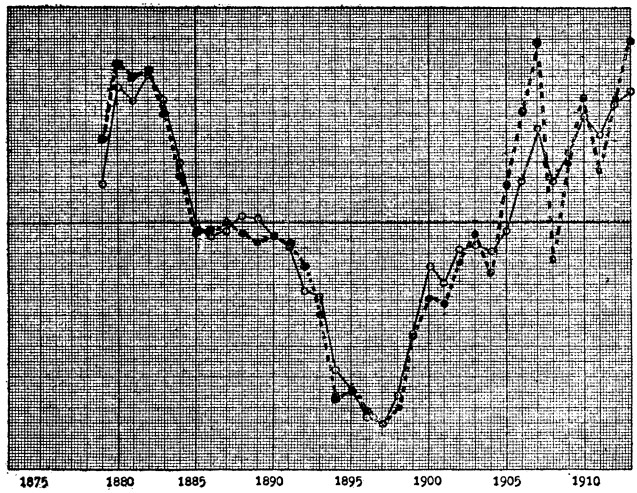

FIGURE 9. - Cycles of wholesale prices (solid line) and of a business barometer (dotted line) constructed by averaging nine series, 1879-1913.

series examined and the cycles of the business barometer, as found above, are given in column two of Table 9, but only for the year of maximum correlation as found when correlating the series with wholesale prices. The coefficients of correlation between the first differences are given in column three of the same table. As would be expected, these coefficients are, as a rule, greater than those

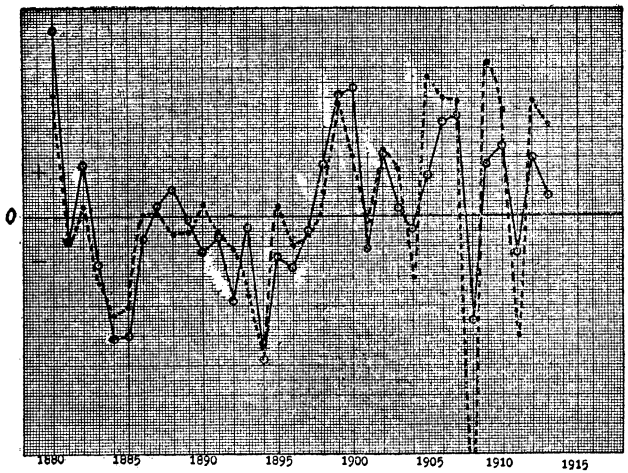

FIGURE 10. - First differences of cycles of wholesale prices (solid line) and of the business barometer (dotted line), 1879-1913.

of Tables 1 and 2. These unusually high coefficients, ranging from +.785 to +.951 for the cycles and from +.516 to +.847 for the first differences, certainly warrant the conclusion that these are homogeneous series. Of course, there is a small element of spurious correlation due to the fact that each series enters the barometer with which it is correlated.

VI. Construction of a One-year Forecaster

The analysis of the twenty-five series of statistics has resulted in the selection of nine series for the construction of a business barometer. The analysis has, at the same time, designated certain other series as having fluctuations preceding those of the business barometer and, therefore, useful in forecasting business cycles. Such series are listed with their coefficients of correlation in the lower part of Table 9. They are: shares sold on the New York Stock Exchange and their average price, the corrected clearing index, new railroad mileage, and percentage of business failures. The corrected clearing index and the average price of shares are the only series having significant coefficients between both cycles and first differences and those of the business barometer; the coefficients being +.795 and +.524 for clearings and +.766 and +.504 for stock prices. One-year forecasters of these two series and of the five series named above (the signs of the items in the series of percentage of business failures being re-

versed) have been computed, the standard deviations being used as the units of the respective series. The resulting relative numbers are presented in Table 10 and, graphically, with the business barometer, in Figure 11. It appears from that figure that the fluctuations of the one-year forecasters do precede by one year, as a rule, those of the business barometer. The coefficients of correlation between the cycles and first differences, respectively, of the average of the five series and the business barometer are +.860 and +.510.

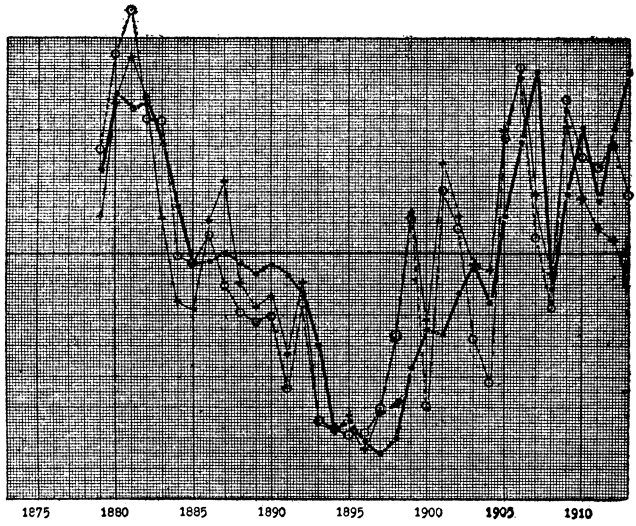

FIGURE 11. - Cycles of business barometer (heavy line), average of corrected clearing index and stock prices (dotted line), and average of five series (light line).

In forecasting, the first differences are of greater significance than the cycles. The information desired is the direction and probable magnitude of the movement of the business barometer next year as compared with this year. There are three series among the five under consideration having a significant degree of correlation between their first differences and those of the business barometer: shares sold, price of shares, and corrected clearings, with coefficients of +.521, +.504, and +.524, respectively. Suppose the adequacy of the three series in forecasting direction of change (not magnitude) be tested:

If the signs of the first differences of the three series be tabulated, if the two or three like signs of any year (plus or minus) be taken to indicate a like direction of change in the business

barometer of the following year, and if the number of agreements and disagreements with the actual change of the business barometer be counted, we obtain the following results:

25 cases of agreement in sign;
9 cases of disagreement in sign.

We may, then, roughly state the degree of accuracy with which direction of change in the business barometer is forecasted as $\frac{25-9}{34} = +0.47$, in a scale in which zero stands for an equal number of agreements and disagreements. Of the nine cases of disagreement, seven of the forecasting signs agree with the business barometer of the same year. This result suggests that the forecasting series do not forecast by exactly a year, but by a varying period, say nine or ten months on the average. A refinement of the present study is thus indicated in which quarterly data would be used and the lag determined for a three, six, nine, or twelve months period.[31]

A moderately high degree of correlation (+.655) has been found between the weighted index numbers of the yield per acre of the nine leading crops (three-year averages) and the business barometer, the latter having a four-year lag. Moore found a coefficient of correlation between cycles in the yield of crops and cycles in general prices lagging four years behind crops (three-year averages in both cases) of +.800.[32] It appears that crop yields for a series of years forecast business conditions for a series of years rather than for any particular year. However, coefficients of correlation based upon three-year averages are extremely difficult to interpret.

VII. Application of Method of Variate Differences

Since making the investigation previously described I have discovered an article on "The Elimination of Spurious Correlation due to Position in Time or Space"[33] which develops a method of dealing with the problem just considered. In that article reference is made to the method of correlating corresponding differences

[31] This study has been made by the writer. Various series have been found that forecast movements in the business barometer by three to nine months.

[32] H. L. Moore, *Economic Cycles*, p. 122.

[33] The Elimination of Spurious Correlation due to Position in Time or Space," by "Student," in *Biometrika*, April, 1914, pp. 179-180.

between successive items (which I had used) in order to eliminate the spurious element of correlation in time series due to a linear connection between the variables and time. A generalization of that method is secured applicable to series of variables which are nth degree functions of time. According to this generalization:

If we wish to determine variability due to position in time or space and to determine whether there is any correlation between the residual variations, all that has to be done is to correlate the 1st, 2d, 3d...nth differences between successive values of our variable with the 1st, 2d, 3d....nth differences between successive values of the other variable. When the correlation between the two nth differences is equal to that between the two $(n+1)$th differences, the value gives the correlation required.[34]

This method has been named by Professor Karl Pearson the *Variate Difference Correlation Method* and it has been applied by him to certain Italian economic data.[35]

The Variate Difference Correlation Method has been applied to the business barometer and the nine series entering therein. The results are given in Table 12. For two series—*i. e.*, gross receipts of railroads and wholesale prices—the coefficients have been computed for the cycles and the 1st to the 6th differences, inclusive, for concurrent pairs and for degrees of lag as indicated in the table. For the remaining seven series the coefficients for the cycles, 1st, 5th, and 6th differences have been found. It will be noticed that in every case except for exports there is a high degree of stability shown by the coefficients for concurrent pairs with the business barometer. Table 13 gives the probable errors of coefficients of correlation for multiple differences, first to sixth, with 35 items in the original series. For a coefficient between sixth differences of .65 the probable error is $\pm$ 13. Judgment based on a coefficient of .65 or more is, therefore, reliable. When the pairings are for a lag in either direction the coefficients are either numerically small or negative. The additional evidence given by application of the new method leads to the following conclusion:

The selection of the series entering into the business barometer is confirmed. The only series concerning which there is a question is exports and its questionability is indicated by the decrease in the coefficient for 1st differences as compared with that for cycles

[34] *Biometrika,* April, 1914, p. 180.

[35] "Numerical Illustrations of the Variate Difference Correlation Method," by Beatrice M. Cave and Karl Pearson, in *Biometrika,* November, 1914, pp. 340-355.

as well as by the decrease in the coefficient for the 5th and 6th differences.

These coefficients, being between series and an index secured by summing them, contain a certain spurious element. However, that element can not be large. On the supposition that *there is no correlation whatever* between a selected series and the remaining series entering into the barometer, the spurious element could not be more than 0.33. In fact, the spurious element is undoubtedly far less, say .05 or less, because the series are highly correlated with each other.

Finally, let me say that before the method of variate differences can be applied with confidence it must be subjected to thorough analysis and experimentation in order that its limitations may be clear. Such analysis I hope to make.

In conclusion, a business barometer has been constructed from nine series of annual figures which were found to fluctuate concurrently with wholesale prices. Other series have been found in which the fluctuations precede those of the business barometer. Further investigation based upon quarterly or monthly data is necessary for the most intelligent use of fundamental statistics in forecasting business conditions.

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